

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

TEST AND CALIBRATION
OF THE
DIGITAL WORLD-WIDE STANDARDIZED SEISMOGRAPH

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1. BACKGROUND

During the past decade there has been steady progress in the modernization of the global seismograph network operated by the U.S. Geological Survey (USGS). The World-Wide Standardized Seismograph Network (WWSSN) has been augmented by new stations with advanced instrumentation, including the Seismic Research Observatories (SRO) and the modified High-Gain Long-Period (ASRO) stations. One goal in the modernization effort has been to improve signal resolution in the long-period band. A second goal has been to generate a global digital data base to support contemporary computer-based analysis and research.

In 1976, a Panel on Seismograph Networks was established by the Committee on Seismology of the National Academy of Sciences to review progress in network seismology and recommend actions that would lead to an improved global data base for seismology. One recommendation in the Panel report (Engdahl, 1977) called for upgrading selected WWSSN stations by the installation of digital recorders. This was viewed as an economical way of expanding the digital network, which had proven itself to be a very promising new tool for earthquake and explosion research. Funds for the development and assembly of 15 digital recorders were provided to the USGS by the Defense Advanced Research Projects Agency and an *ad hoc* panel of scientists was convened by the Committee on Seismology to advise the USGS on the selection of stations to be upgraded and on data recording requirements. A total of 19 digital World-Wide Standardized Seismograph (DWWSS) systems will be operational when all are installed. The additional systems were made available through purchase by the USGS and other organizations; for example, the University of Bergen purchased and installed a DWWSS-type recorder and agreed to furnish the USGS with the data. A list of operational and planned DWWSS network stations is given in Table 1.1.

As one might expect, the digital recorder turned out to be somewhat more sophisticated than the original concept. It was decided to record three components of long-period data continuously, three components of intermediate-period data in an event mode, and the vertical-component short-period data in and event mode (with the capability of adding short-period horizontal channels in the future). Special amplifiers were developed for use with the WWSS seismometers, and a 16-bit fixed-point analog-to-digital converter was chosen

<u>Station</u>	<u>Location</u>	<u>Operating Organizations</u>	<u>Operational Date</u>
AFI	Afiamalua, Western Samoa	Geophysics Division, D.S.I.R., New Zealand	15 May 1981
BDF	Brasilia, Brazil	University of Brasilia	8 June 1982
BER	Bergen, Norway	University of Bergen	10 August 1981
COL	College, Alaska	U.S. Geological Survey	6 January 1982
GDH	Godhavn, Greenland	Geodetic Institute, Denmark	26 August 1982
HON	Ewa Beach, Hawaii	National Weather Service	(1983)
JAS	Jamestown, California	University of California	1 October 1980
KEV	Kevo, Finland	University of Helsinki	14 October 1981
LEM	Lembang, Indonesia	Meteorological & Geophysical Institute	2 June 1982
LON	Longmire, Washington	University of Washington	1 October 1980
QUE	Quetta, Pakistan	Pakistan Meteorological Department	(1983)
SBA	Scott, Antarctica	Geophysics Division, D.S.I.R., New Zealand	(1984)
SCP	State College, Pennsylvania	Penn State University	29 January 1981
SLR	Silverton, South Africa	S.A. Geological Survey	24 October 1981
TAIF	Taif, Saudi Arabia	Directorate-General of Mineral Resources	(1983)
TAU	Hobart, Tasmania	University of Tasmania	10 June 1981
TOL	Toledo, Spain	Geophysical Observatory	3 November 1981
ZRN	Zaria, Nigeria	Ahmadu Bello University	(1983)

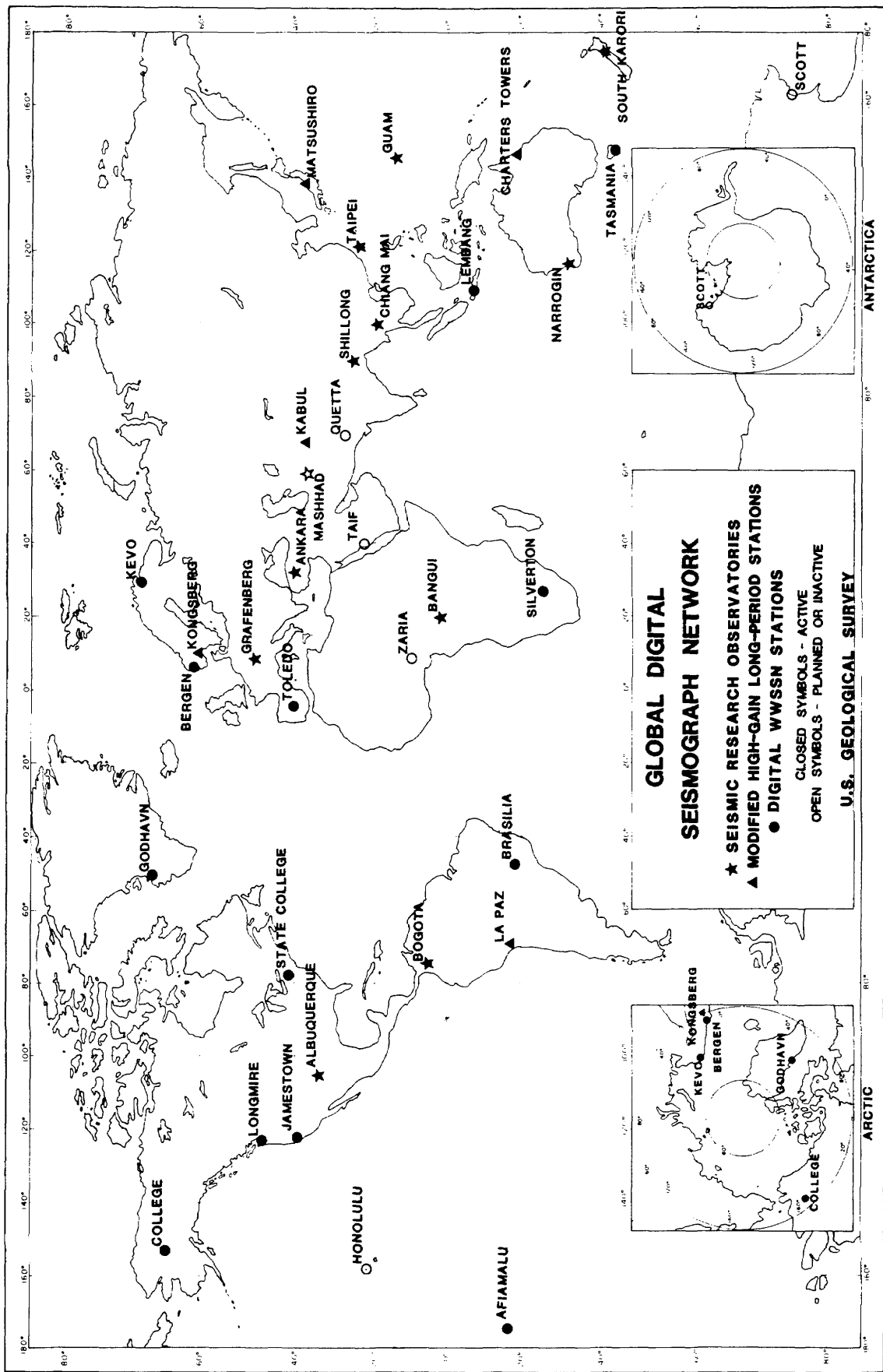
Table 1.1.--List of DWWSSN stations. Anticipated operational dates are shown in brackets.

to provide increased resolution (as opposed to a 16-bit gain-ranged encoder). The microprocessor-based digital recording systems were developed and assembled at the USGS Albuquerque Seismological Laboratory (ASL) and ASL-based technicians began installation at WWSSN stations in 1980.

The current and proposed locations of the DWSSN stations, together with other stations in the Global Digital Seismograph Network (GDSN), are shown on the map in Figure 1.1. A system was operated at Albuquerque for about 18 months, serving as a test bed for evaluation studies. Although the network hardware has been available for some time, the installation of the DWSSN has proceeded slowly. The National Science Foundation supported installation of six stations and the USGS is funding installation of most of the others; however, the network completion date is conjectural because of funding uncertainties.

The DWSSN stations are supported with supplies and technical assistance from ASL (subject to availability of funds). Data recorded on magnetic tapes are mailed to ASL where they are reviewed for quality, then merged with other GDSN station data on the network-day tapes. Hoffman (1980) provides a description of the network-day tape format. Zirbes and Buland (1981) have developed and published user software for reading and interpreting the day tapes.

This report will serve several purposes. One is to provide nominal system transfer functions and calibration information that are needed in the analysis of DWSSN data. A second purpose is to report on an evaluation of operating characteristics (calibration stability, noise levels, and linearity) that may limit the usefulness of the data and to determine if modifications may be needed to improve the data. It is not an exhaustive study in this respect. We continue to depend mostly on data user feedback to point out deficiencies and we solicit comments whenever anomalies are observed in the data.



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Figure 1.1.--Map locations of GDSN stations, including operational and planned DWSSN stations.

2. BRIEF DESCRIPTION OF THE DWWSS SYSTEM

2.1 General

The DWWSS equipment was designed to interface with existing instrumentation used at WWSSN stations without interfering with the production of analog seismograms. Some changes in the analog recording have been necessary, but, for the most part, they have improved the quality of the seismograms. A block diagram of the DWWSS system is shown in Figure 2.1. The two major new components that have been installed at each DWWSSN station are the amplifier assembly and the digital recording system.

The WWSS Benioff seismometers have not been modified for use in the DWWSS system, nor have any other components of the short-period photographic recording system, except for adding a connector on the control box. The WWSS Sprengnether long-period seismometers have been modified in that the original 500-ohm signal coil and calibration coil have been replaced by two 5,000-ohm signal coils wired in series to increase the voltage sensitivity for digital recording. The calibration coil is wound on one of the signal coils. The higher impedance signal coils are not suitable as current sources for driving the WWSS long-period galvanometers; hence, suitably shaped and conditioned signals are derived from the preamplifiers and used to drive .75-second galvanometers to produce the long-period seismograms. This has an added advantage in that the long-period control boxes have been eliminated. These are known to be significant noise sources that often cause "trace stacking" on the seismograms at stations where temperature is not well controlled.

2.2 Amplifier Assembly

The amplifier assembly used in the DWWSS system was designed and manufactured by Teledyne Geotech, Inc. of Garland, Texas. The assembly (see Figure 2.2) consists of three wideband preamplifiers, three intermediate-period (IP) filters, three long-period (LP) filters, one short-period (SP) amplifier/filter combination, and a regulated power supply, all housed in an insulated and shielded enclosure. The inputs to the preamplifiers are derived from the vertical (Z), north (N), and east (E) long-period seismometers. The preamplifiers have a fixed voltage gain of 25 in the signal path used to drive the filters. They also provide signals from a low impedance current source to

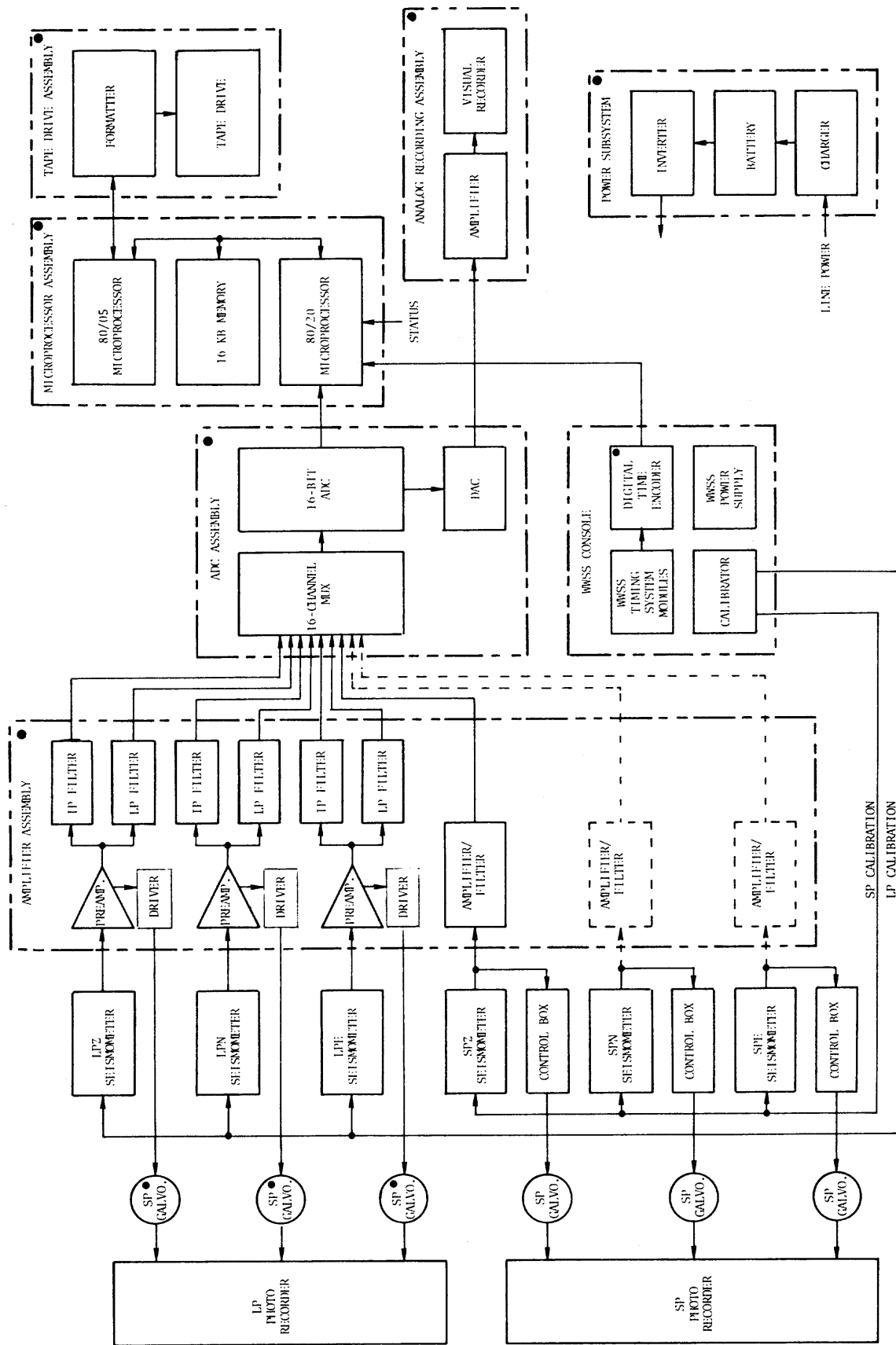


Figure 2.1.--Simplified block diagram of the DWSS system. The bullets designate new equipment that is attached to the WSS instrumentation.